

University of Groningen

## A comparison of confirmatory factor analysis methods

Stuive, Ilse

**IMPORTANT NOTE:** You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*

2007

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Stuive, I. (2007). *A comparison of confirmatory factor analysis methods: Oblique multiple group method versus confirmatory common factor method*. s.n.

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

*Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.*

## References

---

- Arbuckle, J.L., & Wothke, W. (1999). *Amos 4.0 user's guide*. Chicago, IL: SmallWaters.
- Bagozzi, R.P. (1983). Issues in the application of covariance structure analysis: A further comment. *Journal of Consumer Research*, 16, 449 – 450.
- Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior Research Methods*, 37, 379 – 384.
- Bentler, P.M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, 107, 238 – 246.
- Bentler, P.M., & Bonett, D.G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88, 588 – 606.
- Bentler, P.M., & Wu, E.J.C. (1995). *EQS for Windows user's guide*. Encino, CA: Multivariate Software.
- Bernstein, I.H. (1988). *Applied multivariate analysis*. New York: Springer.
- Bollen. K.A. (1989). *Structural Equations with latent variables*. New York: Wiley.
- Bosscher, R.J., & Smit, J.H. (1998). Confirmatory factor analysis of the General Self-Efficacy Scale. *Behaviour Research and Therapy*, 36, 339 – 343.
- Bosscher, R.J., Smit, J.H., & Kempen, G.I.J.M. (1997). Algemene competentieverwachtingen bij ouderen. *Nederlands Tijdschrift voor de Psychologie*, 52, 239 – 248.
- Breckler, S.J. (1990). Applications of covariance structure modeling in psychology: Cause for concern? *Psychological Bulletin*, 107, 260- 273.
- Browne, M.W. (1984). Asymptotically distribution-free methods for the analysis of covariance structures. *British Journal of Mathematical and Statistical Psychology*, 37, 62 – 83.
- Browne, M.W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, 21, 230 – 258.
- Chou, C.-P. & Bentler, P.M. (1990). Model modification in covariance structure modeling: A comparison among likelihood ratio, Lagrange multiplier, and Wald tests. *Multivariate Behavioral Research*, 25, 115 – 136.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.
- Cudeck, R., & Henly, S.J. (1991). Model selection in covariance structure analysis and the “problem” of sample size: A clarification. *Psychological Bulletin*, 109, 512 – 519.

- Curran, P.J., West, S.G., & Finch, J.F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychological Methods*, 1, 16 – 29.
- De Groot, J. I. M., & Steg, L. (2007). Value orientations and environmental beliefs in five countries: Validity of an instrument to measure Egoistic, Altruistic and Biospheric Value Orientations. *Journal of Cross-Cultural Psychology*, 38, 318 – 332.
- De Groot, J. I. M., & Steg, L. (in press). Value Orientations to Explain Environmental Attitudes and Beliefs: How to Measure Egoistic, Altruistic and Biospheric Value Orientations. *Environment and Behavior*.
- Enders, C.K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods*, 12, 121 – 138.
- Fornell, C. (1983). Issues in the application of covariance structure analysis: A comment. *Journal of Consumer Research*, 10, 443 – 447.
- Gerbing, D.W., & Anderson, J.C. (1984). On the meaning of within-factor correlated measurement errors. *Journal of Consumer Research*, 11, 572 – 580.
- Gerbing, D.W., & Hunter, J.E. (1980). *The return to multiple groups: Analysis and critique of confirmatory factor analysis with LISREL*. Unpublished manuscript.
- Gorsuch, R.L. (1983). *Factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Green, S.B., Thompson, M.S., & Babyak, M.A. (1998). A Monte Carlo investigation of methods for controlling Type I errors with specification searches in structural equation modeling. *Multivariate Behavioral Research*, 33, 365 – 384.
- Green, S.B., Thompson, M.S., & Poirier, J. (1999). Exploratory analyses to improve model fit: errors due to misspecification and a strategy to reduce their occurrence. *Structural Equation Modeling*, 6, 113 – 126.
- Green, S.B., Thompson, M.S., & Poirier, J. (2001). An adjusted Bonferroni method for elimination of parameters in specification addition searches. *Structural Equation Modeling*, 8, 18 – 39.
- Guilford, J.P. (1954). *Psychometric Methods*. New York: McGraw-Hill.
- Guttman, L. (1945). Multiple group methods for common-factor analysis: their basis, computations, and interpretations. *Psychometrika*, 17, 209 – 222.
- Guttman, L. (1956). Best possible systematic communality estimates of communalities. *Psychometrika*, 21, 273 – 285.

- Hendriks, P., & Kiers, H.A.L. (1999). *Confirmatory factor analysis methods compared: The multiple group method and maximum likelihood confirmatory factor analysis* (Research report). University of Groningen, Department of Psychology.
- Heywood, H.B. (1931). On finite sequences of real numbers. *Proceedings of the Royal Statistical Society of London*, 134, 486 – 501.
- Hoekstra, R., Finch, S., Kiers, H.A.L., & Johnson, A. (2006). Probability as certainty: Dichotomous thinking and the misuse of p-values. *Psychonomic Bulletin & Review*, 13, 1033 – 1037.
- Holzinger, K.J. (1944). A simple method of factor analysis. *Psychometrika*, 9, 257 – 262.
- Hoogland, J.J. (1998). Robustness of estimators in covariance structure analysis: A Monte Carlo study with a large model. In J.J. Hox & E.D. De Leeuw (Eds.), *Assumptions, robustness, and estimation methods in multivariate modelling* (pp. 67 – 86). Amsterdam: TT- Publikaties.
- Hoogland, J.J. (1999). *The robustness of estimation methods in covariance structure analysis*. Unpublished doctoral dissertation, University of Groningen, The Netherlands.
- Hoogland, J.J., & Boomsma, A. (1998). Robustness studies in covariance structure modeling: An overview and a meta-analysis. *Sociological Methods & Research*, 26, 329 – 367.
- Hu, L.T., & Bentler, P.M. (1998). Fit indices in covariance structure modeling: sensitivity to underparameterized model misspecification. *Psychological Methods*, 3, 424 – 453.
- Hu, L.T., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1 – 55.
- Hu, L.T., Bentler, P.M., & Kano, Y. (1992). Can test statistics in covariance structure analysis be trusted? *Psychological Bulletin*, 112, 351 – 362.
- Hutchinson, S.R. (1998). The stability of post hoc model modifications in confirmatory factor analysis models. *Journal of Experimental Education*, 66, 361 – 380.
- Jöreskog, K.G. (1966). Testing a simple structure hypothesis in factor analysis. *Psychometrika*, 31, 165 – 178.
- Jöreskog, K.G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, 34, 183 – 202.
- Jöreskog, K.G. (1971). Simultaneous factor analysis in several populations.

- Psychometrika*, 36, 409 – 426.
- Jöreskog, K.G., & Sörbom, D. (1988). *LISREL 7: A guide to the program and applications*. Chicago, IL: SPSS.
- Jöreskog, K.G., & Sörbom, D. (2001). *LISREL 8.51*. Chicago: Scientific Software.
- Kaplan, D. (1989). Model modification in covariance structure analysis: Application of the expected parameter change statistic. *Multivariate Behavioral Research*, 24, 285 – 305.
- Lubke, G.H., Dolan, C.V., Kelderman, H., & Mellenbergh, G.J. (2003). On the relationship between sources of within- and between-group differences and measurement invariance in the common factor model. *Intelligence*, 31, 543-566.
- Leamer, E.E. (1978). *Specification searches: Ad hoc inference with nonexperimental data*. New York: Wiley.
- MacCallum, R.C. (1986). Specification searches in covariance structure modeling. *Psychological Bulletin*, 100, 107 – 120.
- MacCallum, R.C. (2003). Working with imperfect models. *Multivariate Behavioral Research*, 38, 113 – 139.
- MacCallum, R.C., Roznowski, M., & Necowitz, L.B. (1992). Model modifications in covariance structure analysis: The problem of capitalization on chance. *Psychological Bulletin*, 111, 490 – 504.
- MacCallum, R.C., & Tucker, L.R. (1991). Representing sources of error in the common factor model: Implications for theory and practice. *Psychological Bulletin*, 109, 502- 511.
- MacCallum, R.C., Tucker, L.R., & Briggs, N.E. (2001). An alternative perspective on parameter estimation in factor analysis and related methods. In R. Cudeck, S. du Toit, & D. Sörbom (Eds.), *Structural equation modeling: Present and future*. (pp. 39 – 57). Lincolnwood, IL: SSI.
- Marsh, H.W., Hau, K-T., Balla, J.R., & Grayson, D. (1998). Is more ever too much? The number of indicators per factor in confirmatory factor analysis. *Multivariate Behavioral Research*, 33, 181 – 220.
- Marsh, H.W., Hau, K-T., & Wen, Z. (2004). In search of golden rules: Comment on Hypothesis-Testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling*, 11, 320 – 341.
- MATLAB7 (2004). The language of technical computing. Natick, MA: The MathWorks, Inc.

- McDonald, R.P. (1989). An index of goodness of fit based on noncentrality. *Journal of classification*, 6, 97 – 103.
- Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance. *Psychometrika*, 58, 525 – 543.
- Muthén, L.K., & Muthén, B.O. (2001). *Mplus: Statistical analysis with latent variables. User's guide* (Version 2). Los Angeles, CA: Muthén & Muthén.
- Nunnally, J.C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.
- Russell, D.W. (2002). In search of underlying dimensions: the use (and abuse) of factor analysis in Personality and Social Psychology Bulletin. *Personality and Social Psychology Bulletin*, 28, 1629 – 1646.
- Saris, W.E., & Stronkhorst, L.H. (1984). *Causal modeling in nonexperimental research: An introduction to the LISREL approach*. Amsterdam: Sociometric Research Foundation.
- Sherer, M., Maddux, J.E., Mercandante, B., Prentice-Dunn, S., Jacobs, B., & Rogers, R.W. (1982). The self-efficacy scale: Construction and validation. *Psychological Reports*, 51, 663 – 671.
- Silvia, E.S.M., & MacCallum, R.C. (1988). Some factors affecting the success of specification searches in covariance structure modeling. *Multivariate Behavioral Research*, 23, 297 – 326.
- Sörbom, D. (1989). Model modification. *Psychometrika*, 54, 371– 384.
- Steg, L., De Groot, J.I.M., Dreijerink, L., Abrahamse, W. & Siero, F.W. (2007). *General antecedents of environmental behaviour: Relationships between values, worldviews, environmental concern, and environmental behaviour*. Manuscript submitted for publication.
- Steg, L., Drijerink, L., & Abrahamse, W. (2005). Factors influencing the acceptability of energy policies: A test of VBN theory. *Journal of Environmental Psychology*, 25, 415 – 425.
- Steiger, J.H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research*, 25, 173 – 180.
- Steiger, J.H. (2000). Point estimation, hypothesis testing, and interval estimation using the RMSEA: Some comments and a reply to Hayduk and Glaser. *Structural Equation Modeling*, 7, 149 – 162.
- Stevens, J. (1996). *Applied multivariate statistics for the social sciences*. New Jersey: Lawrence Erlbaum Ass.
- Tanaka, J.S. (1987). “How big is big enough?”: Sample size and goodness of fit in structural equation models with latent variables. *Child development*, 58, 134 – 146.

- Ten Berge, J.M.F. (1986). Some relationships between descriptive comparisons of components from different studies. *Multivariate Behavioral Research*, 21, 29 – 40.
- Ten Berge, J.M.F. & Kiers, H.A.L. (1991). A numerical approach to the approximate and the exact minimum rank of a covariance matrix. *Psychometrika*, 56, 309 – 315.
- Thurstone, L.L. (1945). A multiple group method of factoring the correlation matrix. *Psychometrika*, 10, 73-78.
- Timmerman, M.E. (2006). Multilevel component analysis. *British Journal of Mathematical and Statistical Psychology*, 59, 301– 320.
- Tucker, L.R., Koopman, R.F., & Linn, R.L. (1969). Evaluation of factor analytic research procedures by means of simulated correlation matrices. *Psychometrika*, 34, 421 – 459.
- Tuerlinckx, F., Ten Berge, J.M.F., & Kiers, H.A.L. (1996). *De multiële groep methode en confirmatorische factor analyse met LISREL: Een vergelijkende studie* (Research Report). University of Groningen, Department of Psychology.
- Wiley, D.E. (1973). The identification problem for structural equation models with unmeasured variables. In A.S. Goldberger & O.D. Duncan (Eds.), *Structural equation models in the social sciences* (pp. 69 – 83). New York: Academic Press.
- Wright, S. (1921). Correlation and causation. *Journal of Agricultural Research*, 20, 557 – 585.
- Wright, S. (1934). The method of path coefficients. *Annals of Mathematical Statistics*, 5, 161 – 215.